Ontario

Apprenticeship
In-school Curriculum Standards

Construction Boilermaker

Level 3

428A

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Introduction

This new curriculum standard for the Construction Boilermaker trade is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum is organized into 3 levels of training. The Program Summary of Reportable Subjects chart summarizes the training hours for each reportable subject.

The curriculum identifies only the learning that takes place off-the-job. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the performance objectives of the Apprenticeship Training Standards. Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on the work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to ensure that all apprentices have achieved the learning outcomes identified in the curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on the job.

Boilermaker

Level 3

Program Summary of Reportable Subjects – Level III

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S0493	Plant Systems and Ancillary Components III	81	56	25
S0494	Rigging and Hoisting III	12	8	4
S0495	Prints and Layouts III	63	30	33
S0496	Applied Trade Calculations III	18	18	0
S0497	Welding and Cutting III	66	25	41
	Total	**240**	**137**	**103**

Number: **S0493**

Reportable Subject: **PLANT SYSTEMS AND ANCILLARY COMPONENTS III**

Duration: Total 81 hours Theory 56 hours Practical 25 hours

Prerequisites: S0488

Content:

S0493.1	Boilers
S0493.2	Pollution Control Equipment
S0493.3	Condensers and Exchangers
S0493.4	Fiberglass Fitting

Evaluation Structure: Assignments related to theory and appropriate application skills.
Final exam at end of term.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
55%	15%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials: Ashton, Bruce J., Garby, Ronald G., IPT's Metal Trades Handbook, IPT Publishing and Training Ltd. 1993.

Recommended Minimum Equipment:

- Tube rolling equipment
- Tube bending equipment
- Tube repair equipment

S0493.1 **Boilers**

Duration: Total 30 hours Theory 20 hours Practical 10 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6007.01 to 6007.05, 6008.01 to 6008.07, 6009.01 to 6009.04, 6010.01, 6010.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform set up and installation procedures required for boiler erection according to government safety regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

On successful completion, the apprentice is able to:

1.1 Describe procedures for the erection of selected component parts of a boiler.

- Rigging, fitting and welding procedures for component erection
- Procedures for erection for:
- Structure
- Drums
- Headers
- Tubes
- Platens
- Buck stays
- Casing
- Fire door
- Super heater elements
- Reheat elements
- Economizer
- Air heater,
- Deaerator
- Water treatment

1.2 Describe boiler tube installation procedures, boiler tube rolling procedures and use of equipment.

- Preparation of tube sheets
- Tube sizes

- Tube material
- Expanding limits
- Fit up of tube
- Tube bending
- Seal welding
- Tack tubes
- Self feed expander
- Retractive
- Lubrication
- Mandrels
- Over rolling
- Under rolling
- Micrometers and gauges
- Belling
- Ferrules
- Repairing leaks
- Testing
- Use of tube rolling/milling equipment

1.3 Describe the operation of a water tube boiler.

1.4 Identify selected steam generator components; state their function, material origin, and any special features:

- Drums and headers
- Platen and buckstays
- Super heater and reheater
- Economizer and air heater
- Deaerator
- Air ducts
- Stacks and breaching
- Condenser
- Fans
- I.D. and F.D.
- Intake and discharge lines
- Precipitators
- Pulverizers
- Stokers
- Burners
- Identify testing required and codes

1.5 Identify boiler tube designation with respect to sizing and quality of material and describe the function of tubes in various arrangements.

1.6 Identify the two basic methods used to fabricate tubes.

1.7 Determine tube bending procedures.

- Long radius bends
- Short radius bends
- Very short radius bends (super heater section)
- Use of field type equipment

1.8 List the methods of tube attachments.

1.9 Describe basic procedures for water boiler tube installation.

- describe the preparation and cleaning process

1.10 Describe a standard propulsive tube expander, a retractive expander and explain the principle of tube expansion.

- Explain the flow of tube material/extrusion
- Work hardening of tube

1.11 Describe adopted tube rolling procedures.

- State upper and lower limitations

1.12 Explain additional operations involving tube forming or welding.

- identify and explain operations such as:

  - rolled and flared
  - rolled and beaded
  - beaded and seal welded
  - rolled and welded
  - rolled and bevel welded
  - expanded by Prosser method
  - possible use of ferrules

1.13 Explain terms that are associated with the tube hole arrangement.

- Circumferential pitch
- Alignment
- Pitch
- Removal space
- Longitudinal pitch
- Diagonal pitch
- Ligament space

1.14 List the tube rolling, checking and measuring devices.

1.15 Define the purpose of tack tubes when rolling.

1.16 Set-up and perform tube rolling operations.

1.17 Set-up and perform tube bending operations.

1.18 Set-up and perform tube installations and tube removals.

1.19 Describe and perform procedures for tube repair(s).

- Explain Boiler code and local regulations
- Identify tube(s) to be repaired
- Mark tube(s) for cutting
- Cut out tube(s)
- Prevent tube blockage
- Prepare existing tube ends and replacement tube(s)
- Fit and tack replacement tube(s)
- Repair tubes taking into consideration variations such as window weld, preparation for different wall thickness

S0493.2 **Pollution Control Equipment**

Duration: Total 6 hours Theory 6 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6010.01, 6010.02, 6012.01

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe construction features of pollution control equipment according to government safety and environmental regulations, manufacturer's recommendations and specifications.

LEARNING OUTCOMES AND CONTENT

2.1 Describe the construction features of:

- Precipitators
- Bag Houses
- Scrubbers
- Selective Catalytic Reducers

S0493.3 **Condensers and Exchangers**

Duration: Total 30 hours Theory 20 hours Practical 10 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6008.01 to 6008.08, 6010.01, 6010.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to assembly and install condensers and exchangers and related components; according to government regulations, manufacturer's recommendations and specifications and approved industry standards.

Learning Outcomes and Content

3.1 Identify types of condensers and exchangers and different design of heat exchangers.

- Single pass
- Multi pass
- Split flow
- Double split flow
- Divided flow
- Cross flow
- Kettle type reboiler
- Design of heat exchangers as classified by the Tubular Exchangers Manufacturers Association (T.E.M.A.) with reference to front stationary head and rear head

3.2 Identify different types of rolled and welded tube materials.

- Seamed or Seamless

3.3 Identify features of heat exchanger and condenser tubes.

- Identify types of material and job application
- Material designation
- Standard sizes and gauges
- Tolerances
- Fabrication and bending procedures

3.4 Identify types of tube bundle construction, their function and installation procedures.

- Baffles
- Tie Rods
- Spacers
- Cage assembly

3.5 Identify four different tube sheet layouts and state their preference of application.

3.6 Determine the pitch for a triangular tube sheet layout.

3.7 Identify the qualities of material for different applications.

3.8 Describe types of heads.

- Channel and removable cover
- Bonnet
- Channel integral with tube sheet
- Pull through and floating head
- Outside packed floating head

3.9 Describe tube rolling procedures for condensers and exchangers.

- Tube sheet layout
- Number of tubes
- Type of metals
- Length of tubes
- Diameter of tube (O.D.)
- Wall thickness of tubes
- Tube sheet or header thickness
- Expansion required
- Lubrication

3.10 List steps associated with tube installation.

3.11 State the recommended tube expansion sequences.

- Refer to tube sheet layout, its area and shape.
- Effects of extrusion

3.12 Calculate the inside diameter of a tube.

3.13 Calculate the expanded diameter of a tube.

3.14 Determine the percentage wall reduction as recommended for ferrous and non-ferrous materials.

3.15 List recommended lubricants.

3.16 Identify the optimum length of expanded seat and explain the reason for grooved seats.

3.17 Identify the factors affecting the quality of an expanded joint.

- Refer to surface of hole
- Roundness of hole
- Cleanliness of hole
- Expansion past the inner edge of tube sheet
- Overheating
- Speed at rolling
- Mechanical properties of tube and tube sheet
- Lubrication or lack of it
- Over expansion and indication of it

3.18 Describe the construction features of rolling equipment used to install condenser and exchanger tubes.

- Compressor
- Air motor
- Electric motor
- Tube expanders
- Roll and mandrels
- Fly cutters
- Tube cutters
- Tube cleaning
- Tube removal tools
- Micrometers
- Torque wrench
- End facing tool

3.19 Describe characteristics of air and electrically powered expander drives.

- Include accessories and controls

3.20 Describe tube end milling equipment, set up and techniques employed.

3.21 Determine the reason for the mandrel conical shape.

3.22 State the purpose of bell roll(s).

3.23 Identify the propulsive type of expander.

3.24 Describe the procedure to locate, remove, replace and test for defects when making repairs to exchangers.

3.25 Identify safety features associated with heat exchangers, testing, inspections and repairs.

3.26 Identify and use specified tools.

- use fly and tube cutters, tube removal tools, torque wrench, micrometers and gauges

3.27 Perform tube expansions into tube sheet.

- Use electrical and air powered expander drives

3.28 Perform tube flaring.

- use flaring tools

3.29 Describe the procedure to locate, remove, replace and test for defects when making repairs to exchangers.

3.30 Inspect for tube leakage.

- Involve removal of cover or bonnet, shell cover and floating head, channel

3.31 Perform hydrostatic test of shell using test ring.

- Test shell types S & T

3.32 Remove the tube bundle, inspect and replace it.

3.33 Assemble the heat exchanger and perform proper stud tightening procedures.

3.34 Perform tube plug installation and identify plug material compatibility related to tube.

S0493.4 **Tank Construction**

Duration: Total 7 hours Theory 2 hours Practical 5 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6000.04, 6010.01, 6010.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform tank shell assembly procedures; according to government safety regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

4.1 Describe the features of tank bases.

4.2 Describe tank floor layout.
- Annular ring
- Lap joint fit up

4.3 Perform tank shell assembly.

4.4 Perform tank layouts.

S0493.5 **Fiberglass Fitting**

Duration: Total 8 hours Theory 8 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6010.01, 6010.02, 6011.01, 6013.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe fiberglass fitting procedures according to government safety regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

5.1 Define the fundamentals of fiberglass fitting procedures:

- Introduction to the fiberglass fitting process
- Advantages of the Fiberglass Reinforced Plastics (FRP)
- Applications of fiberglass in today's industry

5.2 Describe the characteristics of fiberglass materials.

- Resins

- Catalysts
- Fillers
- Accelerators (promoters) and inhibitors
- Other additives

- Selection of Fiberglass Reinforcement.

- Strength
- Chemical, electrical and thermal performance
- Determination of compatible processes
- Optimizing cost/performance

- Types of Reinforcement Materials

  - Roving
  - Woven roving
  - Surfacing mat (veil)
  - Reinforcing mat

- Solvents

5.3 Describe the safe handling and storage of Fiberglass Reinforced Plastics.

- Personal Protection
- Safe Handling
- Proper Storage Practices
- WHMIS Requirements
  - Introduction
  - FRP Materials and WHMIS Labels
  - FRP Material Safety Data Sheets
- Specific Safety Terms Related to FRP

5.4 Describe the Assembly and Repair Procedures for Fiberglass Reinforced Plastic.

- Skills required prior to Assembly and Repair
- Types of FRP Constructions
- Hand Lay - Up
- Spray Lay – Up
- Welding Procedures
- Repairs

Number: **S0494**

Reportable Subject: **RIGGING AND HOISTING III**

Duration: Total 12 hours Theory 8 hours Practical 4 Hours

Prerequisites: S0489

Content:
S0494.1 Advanced Block and Tackle
S0494.2 Rigging Prints

Evaluation Structure: Assignments related to theory and appropriate application skills.
Final exam at end of term.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
50%	20%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Recommended Minimum Equipment:

- Tugger, wire rope.

S0494.1 **Advanced Block and Tackle**

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6009.01, 6009.02, 6009.03, 6009.04, 6010.02, 6011.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform reeving procedures of block and tackle equipment according to job requirements, government safety regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

1.1 Calculate the working load limit derived from formulas to calculate same for all parts.

1.2 Define the choker stress formula.

1.3 Apply the W.L.L. into various load and sling configurations.

1.4 Review the requirements in determining the lead line force
- Determine lead line force when the number of parts and load weight including rope size are known

1.5 Identify factors that determine the amount of wire rope needed for reeving system.

1.6 Name three types of sheaves, friction bearings and the co-efficient of friction
- Express co-efficient of friction in percent

1.7 Hang blocks from structure, reeve the parts required, and reeve and lace multi-part line.

S0494.2 **Rigging Prints**

Duration: Total 4 hours Theory 4 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6000.04, 6009.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to extract information from a rigging print to determine crane and pole positioning according to job requirements.

LEARNING OUTCOMES AND CONTENT

2.1 Extract from a sample rigging print, information required to position a crane or pole for any lift operation.

Number: **S0495**

Reportable Subject: **PRINTS AND LAYOUT III**

Duration: Total 63 hours Theory 30 hours Practical 33 hours

Prerequisites: S0490

Content:

S0495.1	Advanced Layout
S0495.2	Advanced Fitting
S0495.3	Testing of Materials and Welds
S0495.4	Inspection

Evaluation Structure: Assignments related to theory and appropriate application skills.
Final exam at end of term.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
55%	15%	30%

Reference Materials:

Recommended Minimum Equipment:

- Common fitting material (pipe, tubing, plate), common welding equipment, safety equipment, common shop tools.
- Computer lab, CAD software.
- Oxy-acetylene, plasma cutters, arc welders, shop hand tools, safety equipment, layout tools, hand brake.
- Welded samples.
- Samples of fabricated materials.

S0495.1 **Advanced Layout**

Duration: Total 24 hours Theory 9 hours Practical 15 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6003.01, 6003.02, 6007.01

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to develop templates, patterns and drawings and set up power rolling equipment according to manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

1.1 Interpret drawings to layout and fabricate square, round and elliptical holes.

1.2 Develop an elliptical hole opening.
- Employ trammel method
- Employ foci method

1.3 Determine roll and brake capacity and allowances and direction to roll or bend.

1.4 Set up power rolling equipment.
- Recognize how to form a partial cylinder
- Partial cone
- Full ring
- Full cylinder and frustum of a cone

1.5 Develop templates using geometry, parallel lines, radial lines and triangulation.
- Use templates to layout on plate in proper sequence by setting square to required angles and supporting same

1.6 Develop patterns for objects made in the shop.

- Use the triangulation method
- Develop patterns for oblique pyramid

- oblique cone
- square to round transition
- round to square transition
- square to rotated square transition
- square to round oblique transition

1.7 Develop drawings for various projects using CAD software.

S0495.2 **Advanced Fitting**

Duration: Total 15 hours Theory 4 hours Practical 11 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6007.01, 6007.02, 6007.03, 6007.04, 6007.05, 6007.06

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to fit plate units and pipe and shell sections with components according to job requirements, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES AND CONTENT

2.1 Fit pipes and shell section components from drawings.

- Use layout procedure
- Assemble with tools and fitting aids
- Identify misalignment allowances
- fit shells to shells, head to heads, layout on shells, heads, repads and nozzles
- Fit tray rings and downcomer bars, ladder and platform clips, davits, skirts or bases and other miscellaneous components

2.2 Develop patterns for objects fabricated in the shop.

- Use the radial line development method
- Pyramidal shapes (hopper)
- Hopper cut at an angle (truncated)
- Right circular cones with different upper and lower shapes

2.3 Describe how to perform selected fit up operations from drawings.

- Circumferential seams
- Align longitudinal seams
- Shell to shell of equal thickness
- Shell to shell of unequal thickness
- Shell to head
- Reinforcing pads to nozzle and shell
- Repads to heads
- Layout vessel base ring and skirt openings
- Assemble and fit up absorbing tower trays and down comers
- Fabricate and assemble davit parts for vertical and horizontal openings including hinges
- Install a tangential nozzle

S0495.3 **Testing of Materials and Welds**

Duration: Total 9 hours Theory 6 hours Practical 3 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6006.03, 6006.11, 6006.12, 6006.13

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe procedures for destructive and non-destructive testing of materials; according to government regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

3.1 Describe destructive testing methods.

- Describe pull (tensile)
- Bend test
- Elongation (ductility and brittleness)
- Impact testing methods

3.2 Differentiate between destructive and non-destructive testing of material.

3.3 Define the ultimate tensile strength.

3.4 Identify the meaning of yield strength.

3.5 Describe the principle involved in testing steel toughness.

3.6 Describe the free-bend test used in weld testing.

3.7 Describe non-destructive testing methods.

- Describe radiographic
- Ultrasonic
- Dye Penetrant
- Hydrostatic
- Vacuum and Air
- Magnetic Particle
- Eddy Current

3.8 State how a dye penetrant is used in determining the soundness of a weld area.

3.9 Determine how radiographic inspection will show hidden defects in a weld.

3.10 Describe the principle of ultrasonic testing.

3.11 Perform magnetic particle testing on a defective weld using a magnetic particle testing unit.

3.12 Describe applications and limitations of vacuum and air testing.

3.13 Perform visual inspection on welded specimen and summarize its results.

3.14 Explain the principle and scope of gamma-ray testing.

3.15 Explain the principle and scope of magnetic particle testing.

3.16 Explain the principle and scope of eddy current testing.

S0495.4 **Inspection**

Duration: Total 18 hours Theory 11 hours Practical: 4 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6006.07, 6006.13, 6007.05, 6008.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to apply visual dimensional and drawing reference checks and quality and production flow inspection methods according to government regulations, manufacturer's recommendations and specifications and approved industry standards.

LEARNING OUTCOMES AND CONTENT

4.1 Describe the basic concepts and definitions of Quality Control and Inspections.

- Quality
- Quality Control
- Inspection
- Non-conformance
- Factors which influence quality and production
- Methods used to improve productivity

4.2 Describe elements of a Quality Control System.

- Specifications
- Design
- Productions
- Inspection
- Review of usage

4.3 Describe and Compare Codes, Standards and Specifications.

4.4 Define inspection procedures.

4.5 Describe the three stages of Inspection.

- Incoming
- In Process
- Final Inspection

4.6 Inspect and interpret material and welds.

- Define visual inspection
- Soundness, size and shape
- Plate thickness and prescribe quality of material
- Positions of circumferential and longitudinal seams
- Heads, their opening and reinforcement
- Skirt, diameters and minimum thickness
- Base rings and anchor bolt chairs
- Saddles, welded or shipped loose
- Shell openings, limitations and reinforcement
- Internals and removable internals
- Internal/external piping and flanges
- Ladders, platform and lugs
- Ensure fabrication tolerances within limits

4.7 Identify characteristics of acceptable quality of components and parts.

- Code specifications
- Drawing requirements
- General usage

4.8 List factors contingent to production flow in fabrication and assembly of pressure vessels.

- list four factors

4.9 List the types and (stages) of a product quality control.

- list three types

4.10 Describe methods which can be used to improve production and productivity of fabrication processes.

- describe two methods

4.11 Describe the preparation for shipment of a final product with respect to selected components.

- Describe preparation of inside and outside of the vessel
- Finished surfaces
- Circumferential and Longitudinal Seams

- Heads
- Skirts
- Base rings and anchor bolt chairs
- Saddles
- Shell and head openings
- Internals and external piping
- Ladders and platforms
- Name plate
- Flanged openings
- Threaded openings
- Bolts and nuts
- Small parts and loose internals
- Loading and securing the vessel
- Markings and special instructions

Number: **S0496**

Reportable Subject: **APPLIED TRADE CALCULATIONS III**

Duration: Total 18 hours Theory 18 hours Practical 0 hours

Prerequisites: S0491

Content: S0496.1 Advanced Mathematics

Evaluation Structure: Assignments related to theory and appropriate application skills.
Final exam at end of term.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
70%	0%	30%

Instructional and Delivery Strategies:
Lecture and assignment work for layout and fitting procedures.

S0496.1 **Advanced Mathematics**

Duration: Total 18 hours Theory 18 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6003.01, 6003.02, 6007.01, 6007.05

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to apply advanced mathematics required to perform layout and fitting according to manufacturer's recommendations and specifications.

Learning Outcomes and Content

1.1 Compute capacities and weights of:

- Prisms and Cylinders
- Pyramids and Cones
- Spheres

1.2 Solve trade related problems using capacity measures.

1.3 Solve trade related problems using structural shapes.

- Rectangular bar
- Plate or flat bar
- Round bar
- Angle
- Tee
- Channel
- Tubing

Number: **S0497**

Reportable Subject: **WELDING AND CUTTING III**

Duration: Total 66 hours Theory 25 hours Practical 41hours

Prerequisites: S0492

Content:

S0497.1 Cutting and Shielded Metal Arc Welding
S0497.2 Metallurgy and the Welding Process
S0497.3 Heat Treatment

Evaluation Structure: Assignments related to theory and appropriate application skills.
Final exam at end of term.
Periodic quizzes.

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
20%	50%	30%

Instructional and Delivery Strategies:

- Lecture, discussion

Reference Materials: Use of material samples and manufacturer's specifications (CD's, manuals, and internet)

Recommended Minimum Equipment

S0497.1 **Cutting and Shielded Metal Arc Welding**

Duration: Total 51 hours Theory 10 hours Practical 41 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6005.01, 6005.02, 6005.03, 6005.04, 6006.01, to 6006.14

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the cutting process for plasma arc and high pressure water and oxygen lances, interpret welding symbols and perform Shielded Metal Arc Welding procedures according to government safety regulations, manufacturer's recommendations and approved industry standards.

LEARNING OUTCOMES AND CONTENT

On successful completion, the apprentice is able to:

1.1 Explain reasons for selecting a welding machine for a specific task.

1.2 Explain the consideration to be taken when installing an arc welding machine in a shop environment.

1.3 Describe other welding, cutting processes, and welding equipment.

- Gas Tungsten Arc Welding (GTAW)
- Gas Metal Arc Welding (GMAW)
- High frequency welding equipment
- Plasma arc cutting equipment
- Stud welding equipment
- Plastic welding equipment
- Orbital & Overlay welding
- Spray Metal Arc
- High Pressure Water and Oxygen Cutting Lances

1.4 Set up arc air gouging equipment safely.

- Set up without causing damage to the equipment and its accessories

1.5 Determine specifications and procedures for each welding operation according to the Canadian Welding Bureau W178.1.

- Joint spacing

- Holding clamping devices
- Number and spacing of tack welds
- Pre-setting/distortion allowances of joint member
- Current type
- Polarity and Voltage

1.6 Interpret welding symbols as standardized by the American Welding Society.

- Parts
- Materials preparation
- Weld types
- Dimensioning
- Position
- Execution (field or shop)
- Finish (flush, chip or grind)

1.7 Weld stringer beads on:

- Mild steel, in the overhead position, using E6010 or E6011 and E7018 filler material, with 1/8, and 5/32 rod.

1.8 Weld laps joints on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.9 Weld butt joints on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8 and 5/32 rod.

1.10 Weld tee joints on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8 and 5/32 rod.

1.11 Weld a corner joint on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8 and 5/32 rod.

1.12 Perform a fillet weld to install a pad on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.13 Perform a fillet weld using a weaving pattern by applying a crescent, figure 8, and rotary motion on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.14 Perform a single pass fillet weld on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.15 Perform a multiple pass fillet weld on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.16 Perform a single pass corner joint weld on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.17 Perform a multiple pass corner joint weld on:

- Mild steel, in the overhead position, using E6010 and E7018 filler material, with 1/8, and 5/32 rod.

1.18 Set up GTAW and GMAW equipment.

- set up safely and without causing damage to equipment and its accessories.

1.19 Set up arc air gouging equipment.

- set up safely without causing damage to equipment and its accessories

1.20 Remove base material using arc air gouging equipment.

- Remove base material with safely while retaining a sound weld

1.21 Demonstrate acceptable safe welding procedures.

- Prevent distortion, and produce a sound weld without visible defects, for joints.

S0497.2 **Advanced Metallurgy**

Duration: Total 6 hours Theory 6 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6006.01, 6006.02, 6006.03, 6006.04, 6006.14

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to explain concepts in metallurgy including the effect of alloys on the cutting action, heat straightening and hot and cold working according to sound scientific and principles of physics.

LEARNING OUTCOMES AND CONTENT

2.1 Determine the effect of carbon regarding the weldability and flame cutting of steel.

2.2 Determine the effect of alloys regarding weldability and cutting action in steels.

2.3 Explain the principle of heat straightening methods.

2.4 Explain the significance of cold working metals.

2.5 List the advantages of hot working metals.

2.6 Describe the effect to the mechanical and physical properties of metals after hot and cold forming.

S0497.3 **Heat Treatment**

Duration: Total 9 hours Theory 9 hours Practical 0 hours

Prerequisites: Level II

Cross-Reference to Training Standard: 6006, 6007.04, 6007.05, 6008.06, 6008.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe heat treatment including steel manufacturing methods and effects of heat treatment according to sound principles of metallurgy, manufacturer's recommendations and specifications.

LEARNING OUTCOMES AND CONTENT

3.1 Describe the forming of steel from the ingot stage to the finished product for:

- Plates
- Sheets
- Bars
- Rods
- Tubes
- Rails
- Pipes
- Structural shapes

3.2 Define terms in heat treatment.

- Hot rolled
- Cold rolled
- Tempered
- Annealed
- Normalized
- Galvanized

3.3 Identify selected steels and their carbon content.

- AISI C1016, AISI C1030, AISI C1085

3.4 Interpret the SAE/AISI for a given plain carbon steel.
- Determine carbon content
- Method of manufacture
- Weldability

3.5 Interpret the ASTM specification for a given plain carbon steel.
- Determine strength
- Usage
- Weldability

3.6 Identify major sources of heat used for heat treatment.
- Identify flame
- Natural gas and compressed air
- Annealing furnace or ovens

3.7 Identify factors which are contingent to hardening of steel.
- Identify three factors

3.8 List processes used for case hardening of metals.
- list three processes

3.9 List reasons for tempering some metal after heat treating.

3.10 Describe procedures for controlling hardness in the heat affected zone of a weld.

3.11 List three rules which help in determining the need for preheating carbon steel prior welding.

3.12 List four advantages in preheating of carbon steel for metal arc welding.

3.13 Identify effects of various stages of heat treatment.

- Stress Relieving
- Annealing
- Normalizing
- Preheating
- Post Heating

3.14 Describe grain structures for:
- Ferrite
- Cementite
- Pearlite
- Austenite
- Martensite

3.15 Describe normalizing and annealing processes and give reasons for them.

3.16 Describe post-weld heating to:

- Relieve stresses
- Improve toughness
- Increase strength and ductility

3.17 Describe stress relieving as a post-weld method to:

- Reduce residual stresses
- Improve service life of the weldment

3.18 Describe the importance of correct temperatures and correct heating and cooling rates.

3.19 Describe measures to control and check temperatures during pre- and post-weld heating.

3.20 Describe the influence of rate of heating, time at temperature, rate of cooling on the micro-structure of the weld area.

POWER SOURCES AND EQUIPMENT	QUANTITY
SMAW (CC) (AC/DC) power source and equipment	1 per apprentice
GTAW (CC), AC/DC, high frequency, square wave, pulsed power source and equipment, water-cooled torch, foot controller	1 per 5 apprentices
GMAW / FCAW (CV) power source and equipment (Capable of Spray-transfer)	1 per apprentice
GMAW-PULSED power source and equipment	1 per 5 apprentices
Plasma arc cutting power source and equipment	1 per 5 apprentices
Air-Carbon-Arc-Gouging power source and equipment	1 per 5 apprentices
Oxy-fuel-gas manual cutting equipment	1 per apprentice
Oxy-fuel-gas semi-automatic cutting equipment	1 per 5 apprentices
Oxy-fuel-gas-heating torch and equipment	1 per 5 apprentices
Approved electrode storage oven	1 per shop
Compressed air supply (80-100 psi)	1 per shop

MIG, TIG Equipment

FABRICATION MACHINES (1 each per shop)

Band saw
Nibbler
Ironworker
Pedestal grinders
Cut-off abrasive wheel saw
Weld-bevel preparation equipment for plate and pipe
Weld-coupon bending apparatus
Approved smoke extraction/air make-up unit
Welding and fabricating shops must be well lit, appropriately heated and ventilated

BASIC HAND TOOLS AND EQUIPMENT	TOOL CRIB TO COVER CLASS SIZE
Adjustable wrenches (various sizes)	Pliers (needle nose, slip joint)
Allen wrenches (metric and imperial)	Positioners
Bench vice	Pry bars
"C" clamps (various sizes)	Punches
Chalk-line	Screwdrivers (slot, Phillips, Robertson, various sizes)
Cold chisels (various sizes)	

Electric extension cords
Files (flat, half-round, rat-tail, bastard)
Friction lighter
Grinders, grinding and sanding disks (for carbon steel, aluminum and stainless steel)
Hacksaw
Hammers (chipping, ball peen, claw, sledge, various sizes)
Hand shears
Layout table
Magnets
Metal markers
Pipe clamps
Pipe cutter
Pipe wrenches
Scribers
Snips (heavy duty sheet metal cutting)
Soapstone markers
Socket sets (metric and imperial)
Temperature indicating crayons
Tip cleaners
Toolboxes
Tungsten sharpening grinders
Vice grips (various sizes and types)
Wire brushes (for carbon steel, aluminum and stainless steel)
Wire cutters
Work bench
Wrench sets (open and closed ends, both metric and imperial)

MEASURING TOOLS

Drafting equipment
Combination square
Fillet gauges
Spirit level
Vernier caliper

TOOL CRIB TO COVER CLASS SIZE

Square
Straight edge
Scriber
Micrometer
Tape measure

SAFETY EQUIPMENT

(1 per apprentice)

Earplugs and muffs
Face shields
Fire blankets
Fire extinguishers
Goggles
Leather aprons
Leather gloves
Leather jackets
Masks (particle, vapour)
Respirators
Safety glasses